

AD-A284 903



①

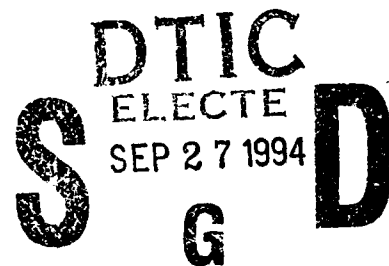
RL-TR-88-316, Updated
Final Technical Report
September 1994



GRAPHICAL AIDS FOR THE USERS OF GEMACS (GAUGE): RAY TRACING ENHANCEMENTS

Decision-Science Applications, Inc.

Jeffrey A. Evans and Edgar L. Coffey



APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED.

Rome Laboratory
Air Force Materiel Command
Griffiss Air Force Base, New York

2178 94-30794

94 9 20 057

This report has been reviewed by the Rome Laboratory Public Affairs Office (PA) and is releasable to the National Technical Information Service (NTIS). At NTIS it will be releasable to the general public, including foreign nations.

RL-TR-88-316 (UPDATED) has been reviewed and is approved for publication.

APPROVED:



KENNETH R. SIARKIEWICZ
Project Engineer

FOR THE COMMANDER:



JOHN J. BART, Chief Scientist
Reliability Sciences
Electromagnetics & Reliability Directorate

If your address has changed or if you wish to be removed from the Rome Laboratory mailing list, or if the addressee is no longer employed by your organization, please notify RL (ERST) Griffiss AFB NY 13441. This will assist us in maintaining a current mailing list.

Do not return copies of this report unless contractual obligations or notices on a specific document require that it be returned.

REPORT DOCUMENTATION PAGE			Form Approved OMB No. 0704-0188	
<small>Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.</small>				
1. AGENCY USE ONLY (Leave Blank)	2. REPORT DATE September 1994	3. REPORT TYPE AND DATES COVERED Final Jan 93 - Jul 93		
4. TITLE AND SUBTITLE GRAPHICAL AIDS FOR THE USERS OF GEMACS (GAUGE): RAY TRACING ENHANCEMENTS		5. FUNDING NUMBERS C - F30602-93-C-0022 PE - 64256F PR - 3321 TA - 03 WU - P2		
6. AUTHOR(S) Jeffrey A. Evans and Edgar L. Coffey				
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Decision-Science Applications, Inc. 1110 N. Glebe Road Suite 400 Arlington VA 22201		8. PERFORMING ORGANIZATION REPORT NUMBER DSA Report #105/1460		
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) Rome Laboratory (ERST) 525 Brooks Road Griffiss AFB NY 13441-4505		10. SPONSORING/MONITORING AGENCY REPORT NUMBER RL-TR-88-316, Updated		
11. SUPPLEMENTARY NOTES Rome Laboratory Project Engineer: Kenneth R. Siarkiewicz/ERST/(315) 330-2465				
12a. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution unlimited.		12b. DISTRIBUTION CODE		
13. ABSTRACT (Maximum 200 words) <p>This report contains update pages for RADC-TR-88-316, same title. The capability to plot rays from source points to observation points via multiple scattering centers has been added to the original suite of operations available in the original GAUGE package. This is useful for antenna design and system integration studies.</p> <p style="text-align: center;">DTIC TAB Unannounced Justification: By GPO Distribution Statement DTIC TAB Unannounced Justification: By GPO Distribution Statement</p>				
14. SUBJECT TERMS GEMACS, Modeling & Simulation, Graphics, Uniform Theory of Diffraction (UTD), Geometric Theory of Diffraction (GTD)			15. NUMBER OF PAGES 32	
			16. PRICE CODE	
17. SECURITY CLASSIFICATION OF REPORT UNCLASSIFIED	18. SECURITY CLASSIFICATION OF THIS PAGE UNCLASSIFIED	19. SECURITY CLASSIFICATION OF ABSTRACT UNCLASSIFIED	20. LIMITATION OF ABSTRACT UL	

Table of Contents

<u>Section</u>	<u>Page</u>
TABLE OF CONTENTS	iii
LIST OF FIGURES.....	xi
ACRONYMS & ABBREVIATIONS	xv
NOTATION.....	xviii
A. INTRODUCTION.....	A.1-1
A.1 SUMMARY AND OVERVIEW	A.1-1
A.2 GAUGE DESCRIPTION AND NOMENCLATURE	A.2-1
A.2.1 Hardware Required	A.2-2
A.2.2 Synopsis of GAUGE Features	A.2-2
A.2.3 Interfacing with GEMACS	A.2-3
A.2.4 Program Statistics	A.2-7
A.3 MENU STRUCTURE.....	A.3-1
A.4 GAUGE MODELING EXAMPLES.....	A.4-1
A.4.1 AIM-7 Illuminator.....	A.4-1
A.4.2 MOM Modeling of Cavity-Backed Spiral	A.4-2
A.4.3 Antenna Near Field Distribution on Shipborne Platform	A.4-3
A.5 REPORT ORGANIZATION.....	A.5-1
B. GETTING STARTED	B.1-1
B.1 INTRODUCTION.....	B.1-1
B.2 GAUGE INSTALLATION	B.2-1
B.3 MENUS	B.3-1
B.3.1 Help Feature	B.3-2
B.4 READING FILES	B.4-1
B.5 SAMPLE SESSION.....	B.5-1
B.5.1 Playback File.....	B.5-1
B.5.2 GAUGE GP Preprocessor Option Sample Session	B.5-3
B.5.2.1 Entering the Graphic Processor (GP)	B.5-3
B.5.2.2 Problem Definition and Adding Points.....	B.5-5
B.5.2.3 Adding a Plate	B.5-7
B.5.2.4 Translating to Form a Cube.....	B.5-7
B.5.2.5 Editing Plate Normals	B.5-8
B.5.2.6 Saving the Cube Geometry.....	B.5-9
B.5.2.7 Converting from Plates to Wires	B.5-10
B.5.2.8 Deleting Duplicates.....	B.5-10

<input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	
Codes	
Dist	Avail and/or Special
A-1	

Table of Contents

<u>Section</u>	<u>Page</u>
B.5.2.9 Checking Model Statistics and Renumbering ...	B.5-11
B.5.3 GAUGE/GEMACS Interaction	B.5-13
B.5.3.1 Using GAUGE to Create a GEMACS MOM Deck	B.5-13
B.5.3.2 Creating a GEMACS GTD Deck	B.5-15
B.5.3.3 Running GEMACS	B.5-16
B.5.4 Displaying Data with GP Post-Processor Option	B.5-18
B.5.4.1 Current Mapping with Color	B.5-18
B.5.4.2 Annotating the Display	B.5-19
B.5.4.3 Display of E Field Pattern	B.5-20
B.6 GRAPHICAL PROCESSOR HINTS	B.6-1
B.6.1 "Num Lock" Key	B.6-1
B.6.2 Adding Points	B.6-1
B.6.3 Coord Cards	B.6-1
B.6.4 Adding Cylinders	B.6-1
B.6.5 Translate/Rotate	B.6-2
B.6.6 Delete	B.6-2
B.6.7 Insufficient Memory	B.6-2
C. GAUGE GRAPHICAL PROCESSOR	C.1-1
C.1 INTRODUCTION	C.1-1
C.1.1 Graphical Processor Database Structure	C.1-3
C.1.2 Graphical Processor Menu Structure	C.1-4
C.1.3 Plotting 3-Dimensional Models on a 2-D Screen	C.1-5
C.1.4 Programming Considerations	C.1-7
C.1.4.1 Language Choice	C.1-7
C.1.4.2 Menus	C.1-8
C.1.4.3 Graphic Drivers	C.1-8
C.1.4.4 Utility Subroutines	C.1-9
C.1.4.5 Documentation	C.1-10
C.2 READING AND VIEWING A MODEL	C.2-1
C.2.1 GAUGE Subset of GEMACS Geometry Commands	C.2-1
C.2.2 Reading Files	C.2-2
C.2.2.1 Merge	C.2-2
C.2.3 View Options	C.2-2
C.2.3.1 Rotate	C.2-3
C.2.3.1.1 Pitch/Yaw	C.2-3
C.2.3.1.2 User Defined	C.2-4
C.2.3.1.3 Isometric	C.2-4
C.2.3.1.4 Global Planes	C.2-4
C.2.3.2 Scale	C.2-5
C.2.3.3 Zoom	C.2-5
C.2.3.4 Translate by Point	C.2-6

Table of Contents

<u>Section</u>	<u>Page</u>
C.2.3.5 Translate by Box.....	C.2-6
C.2.3.6 Unzoom/Trans.....	C.2-7
C.2.3.7 Aspect Ratio.....	C.2-7
C.2.4 Parameters.....	C.2-8
C.2.4.1 Hidden Surface.....	C.2-8
C.2.4.2 Shrink.....	C.2-9
C.2.4.3 Shrink Ratio.....	C.2-9
C.2.4.4 Point IDs.....	C.2-10
C.2.4.5 Plate, Wire and Patch IDs.....	C.2-10
C.2.4.6 Erase Screen.....	C.2-11
C.2.4.7 Debug.....	C.2-11
C.2.4.8 Skeleton.....	C.2-11
C.2.4.9 Skeleton Angle.....	C.2-12
C.2.4.10 Contour.....	C.2-12
C.2.4.11 Normals.....	C.2-13
C.2.5 Show/Noshow.....	C.2-13
C.2.5.1 Selection Methods.....	C.2-14
C.2.5.1.1 Plate, CP, PA ID.....	C.2-14
C.2.5.1.2 Other Geometry.....	C.2-15
C.2.5.1.3 Type.....	C.2-15
C.2.5.1.4 Box.....	C.2-15
C.2.5.1.5 Current.....	C.2-15
C.2.5.1.6 Restore.....	C.2-16
C.2.5.1.7 Swap.....	C.2-16
C.2.5.1.8 Recently Added.....	C.2-16
C.2.5.1.9 Radius.....	C.2-16
C.2.5.1.10 Conductivity.....	C.2-16
C.2.5.1.11 Noshow Points.....	C.2-17
C.2.5.1.12 Show Points.....	C.2-17
C.2.5.2 Choosing a Show Status.....	C.2-17
C.2.5.2.1 Show Only.....	C.2-18
C.2.5.2.2 Noshow Only.....	C.2-18
C.2.5.2.3 Show.....	C.2-18
C.2.5.2.4 Noshow.....	C.2-18
C.2.5.3 Show/Noshow Examples.....	C.2-18
C.3 PREPROCESSOR.....	C.3-1
C.3.1 Add Entity.....	C.3-1
C.3.1.1 Add Point.....	C.3-2
C.3.1.2 Add Wire (CP).....	C.3-2
C.3.1.3 Add Plate.....	C.3-3
C.3.1.4 Add Patches.....	C.3-4
C.3.1.5 Add Apertures.....	C.3-4
C.3.1.5.1 Add Aperture on Cylinder (AP_CY).....	C.3-5
C.3.1.5.2 Add Aperture on End Cap (AP_EC).....	C.3-5

Table of Contents

<u>Section</u>	<u>Page</u>
C.3.1.5.3 Add Aperture on Plate (AP_PL).....	C.3-6
C.3.1.5.4 Add Aperture Points (AP_PT_XX)	C.3-7
C.3.1.6 Add Coordinate System	C.3-8
C.3.1.7 Add Cylinder	C.3-9
C.3.1.7.1 Add End Caps	C.3-9
C.3.1.8 Add Radius.....	C.3-10
C.3.1.9 Add Conductivity.....	C.3-11
C.3.2 Editing.....	C.3-11
C.3.2.1 Editing Points	C.3-12
C.3.2.2 Editing Wire Radius	C.3-12
C.3.2.3 Editing Plate Conductivity.....	C.3-12
C.3.2.4 Editing Plate Normals	C.3-13
C.3.3 Renumbering.....	C.3-13
C.3.4 Integrity	C.3-14
C.3.5 Deleting	C.3-14
C.3.5.1 Deleting Points	C.3-15
C.3.5.2 Deleting Plates, Wires and Patches	C.3-15
C.3.5.3 Deleting Other Geometry	C.3-16
C.3.5.4 Deleting Duplicates	C.3-16
C.3.5.5 Deleting Noshow Items.....	C.3-17
C.3.5.6 Deleting Recently Added Entities	C.3-17
C.3.5.7 Deleting All Geometry	C.3-17
C.3.6 Translate/Rotate.....	C.3-18
C.3.6.1 Translation.....	C.3-19
C.3.6.2 Rotation.....	C.3-19
C.3.6.3 Move Original.....	C.3-20
C.3.6.4 Copy Geometry	C.3-20
C.3.6.5 Connecting Geometry	C.3-20
C.3.7 Reflect	C.3-22
C.3.7.1 Move Original.....	C.3-23
C.3.7.2 Project.....	C.3-24
C.3.7.3 Copy Geometry	C.3-24
C.3.7.4 Connecting Geometry	C.3-24
C.3.8 Save Model.....	C.3-24
C.3.9 Converting.....	C.3-25
C.3.9.1 Plates to Wires.....	C.3-25
C.3.9.2 Wires to Plates.....	C.3-25
C.3.9.3 Dummy to Plates.....	C.3-26
C.3.9.4 Plates to Patches.....	C.3-26
C.3.10 Lines, Parabolas, Circles and Arcs.....	C.3-27
C.3.11 Picking Points	C.3-28
C.4 POSTPROCESSOR.....	C.4-1
C.4.1 Reading Plate, Wire and/or Patch Data.....	C.4-1
C.4.2 2-D Plotting.....	C.4-2

Table of Contents

<u>Section</u>		<u>Page</u>
	C.4.2.1 Reading 2-D Plot Data.....	C.4-3
	C.4.2.2 Rectangular Plotting	C.4-3
	C.4.2.3 Setting Plot Labels.....	C.4-5
	C.4.2.4 Polar Plotting.....	C.4-6
C.4.3	Contours.....	C.4-7
	C.4.3.1 Reading a Contour File	C.4-8
C.4.4	Color	C.4-9
	C.4.4.1 Color by ID	C.4-10
	C.4.4.2 Color by Depth	C.4-11
	C.4.4.3 Invert.....	C.4-11
	C.4.4.4 Color OFF	C.4-11
	C.4.4.5 Color by Current.....	C.4-12
	C.4.4.6 Color by Type.....	C.4-12
	C.4.4.7 Color by Radius	C.4-13
	C.4.4.8 Color by Conductivity.....	C.4-13
	C.4.4.9 Color by Location in Memory	C.4-13
C.4.5	Ray Path Visualization	C.4-14
	C.4.5.1 Ray Path Plotting.....	C.4-14
	C.4.5.1.1 Read Ray Data... ..	C.4-15
	C.4.5.1.2 Plot Rays.....	C.4-16
	C.4.5.1.3 Number Rays.....	C.4-17
	C.4.5.1.4 Color Rays	C.4-17
	C.4.5.1.5 Ray Plotting Options	C.4-18
	C.4.5.2 Ray Paths on Cylinder Example.....	C.4-21
C.5	SCREEN ENHANCEMENTS AND UTILITIES.....	C.5-1
	C.5.1 Text/Axes/etc.....	C.5-1
	C.5.1.1 Text.....	C.5-1
	C.5.1.2 Axes	C.5-2
	C.5.1.3 Date/Time.....	C.5-2
	C.5.1.4 Box.....	C.5-2
	C.5.1.5 Legend.....	C.5-3
	C.5.1.6 Put Line.....	C.5-4
	C.5.1.7 Put Arrow.....	C.5-4
	C.5.1.8 Find Distance.....	C.5-4
	C.5.1.9 Unframe Window.....	C.5-5
	C.5.2 Utilities.....	C.5-5
	C.5.2.1 Playback Files	C.5-5
	C.5.2.1.1 Create	C.5-6
	C.5.2.1.2 Read Playback.....	C.5-6
	C.5.2.1.3 End Processing.....	C.5-7
	C.5.2.2 Model Statistics	C.5-7
	C.5.2.3 Screen Erase.....	C.5-8
	C.5.3 Creating Cut and Paste Effects	C.5-8
C.6	HARD COPY.....	C.6-1

Table of Contents

<u>Section</u>	<u>Page</u>
C.6.1 Screen Dump	C.6-1
C.6.2 Pen Plotter	C.6-2
C.6.3 See HPGL File	C.6-3
C.6.4 Optimizing an HPGL File	C.6-3
C.6.5 Laser Plot	C.6-4
C.6.6 Laser File	C.6-5
 D. GAUGE INPUT TRANSLATOR/MACRO PROCESSOR	 D.1-1
D.1 GEMACS/GAUGE INPUT TRANSLATOR	D.1-1
D.1.1 Purpose and Function	D.1-1
D.1.2 Using the Translator	D.1-2
D.1.2.1 Defining Library Paths	D.1-3
D.1.2.2 Specifying Input and Output Files	D.1-4
D.1.2.3 Specifying Input and Output Languages	D.1-4
D.1.2.4 The DEBUG Capability	D.1-5
D.1.2.5 Graphical Database	D.1-6
D.1.2.6 Saving Execution Commands and Comments	D.1-6
D.1.2.7 Macro Modeling Capability of the Translator	D.1-7
D.1.3 Installation	D.1-8
D.1.3.1 Source Code	D.1-9
D.1.3.2 Macro Library Files	D.1-10
D.1.3.3 Geometry Examples	D.1-10
D.2 GEMACS TRANSLATOR MACRO PROCESSOR	D.2-1
D.2.1 Introduction, Purpose, and Capabilities	D.2-1
D.2.1.1 Basic Macro Library Structure	D.2-1
D.2.1.2 Basic Macro Library Capabilities	D.2-4
D.2.1.2.1 Replaceable Parameters	D.2-4
D.2.1.2.2 MLP Commands	D.2-5
D.2.1.2.3 MLP Arithmetic Operations	D.2-5
D.2.1.3 Macro Library Processor Commands	D.2-7
D.2.1.3.1 MLP &DEBUG Command	D.2-7
D.2.1.3.2 MLP &CALL Command	D.2-8
D.2.1.3.3 MLP &MACRO - &MEND Commands	D.2-8
D.2.1.3.4 MLP &LOOP - &LABEL Commands	D.2-9
D.2.1.3.5 MLP &IF-&THEN-&ELSE-&ENDIF	D.2-11
D.2.1.3.6 MLP &INPUT Command	D.2-12
D.2.1.3.7 MLP &OUTPUT Command	D.2-12
D.2.1.3.8 MLP &JUMP Command	D.2-13
D.2.1.4 Macro Library Processor Functions	D.2-13
D.2.2 Using the Macro Library	D.2-14

Table of Contents

<u>Section</u>	<u>Page</u>
D.2.2.1 Using Existing Macro Models	D.2-14
D.2.2.2 Adding Macro Models to the Library	D.2-16
D.2.2.3 Adding New Operators to the Library	D.2-18
D.2.2.3.1 Changes to Block Data	D.2-19
D.2.2.3.2 Changes to the FORTRAN	D.2-21
D.2.2.4 Adding New Macro Commands to the MPL	D.2-22
D.2.2.4.1 Changes to Block Data	D.2-22
D.2.2.4.2 Changes to the FORTRAN	D.2-22
E. GAUGE/GEMACS OUTPUT TRANSLATOR	E.1-1
E.1 INTRODUCTION	E.1-1
E.2 USING GMOUT	E.2-1
E.2.1 Geometry from ASCII File	E.2-2
E.2.2 Current and Fields from ASCII File	E.2-4
E.2.3 Currents and Fields from Binary File	E.2-6
E.2.4 Use with Various GEMACS Options	E.2-8
E.3 ENHANCING GMOUT	E.3-1
E.3.1 Translating GEMACS ASCII Files	E.3-1
E.3.2 Translating GEMACS Binary Files	E.3-2
E.3.2.1 Binary File Format	E.3-3
E.3.2.2 Binary File with Field Data	E.3-6
E.3.2.3 Binary File with Current Data	E.3-9
E.4 REHOSTING GMOUT ON ANOTHER COMPUTER SYSTEM	E.4-1
F. GAUGE SOFTWARE PROGRAM DOCUMENTATION	F.1-1
F.1 INTRODUCTION	F.1-1
F.2 GRAPHICAL PROCESSOR SOFTWARE DOCUMENTATION	F.2-1
F.3 INPUT TRANSLATOR/MACRO PROCESSOR DOCUMENTATION	F.3-1
F.4 GEMACS/GAUGE OUTPUT TRANSLATOR DOCUMENTATION	F.4-1
G. REFERENCES	G.1-1
H. APPENDICES	
A. Directories of Release Disks and File Functions	App. A-1
B. Subset of GEMACS Commands Interpreted by GAUGE GP	App. B-1
C. Standard File Extensions	App. C-1
L. INDEX	I.1-1

List of Figures

<u>Figure</u>	<u>Page</u>
A.2.1 GAUGE / GEMACS Interface	A.2-1
A.2.2 GEMACS Related and GAUGE Graphical Features	A.2-3
A.2.3 Interface Functional Flow	A.2-4
A.2.4 GP Pre-Processor Option	A.2-5
A.2.5 GP Post-Processor Option	A.2-6
A.3.1 GAUGE Top Level Menu	A.3-1
A.3.2 First Level of Submenus in the GP Menu Tree	A.3-3
A.4.1 Polar Antenna Patterns	A.4-2
A.4.2 EM Coupling Between Antennas	A.4-2
A.4.3 Cavity-Backed Spiral	A.4-3
A.4.4 Far Field Pattern	A.4-3
A.4.5 MOM Model of a Ship	A.4-4
A.4.6 Antenna Locations	A.4-4
A.4.7 E-Field Mapping Using Zoom and Grey Scale	A.4-5
B.3.1 On-Line Help Utility	B.3-2
B.5.1 Model of a Cube	B.5-5
B.5.2 Four Points on Screen	B.5-6
B.5.3 Plate with Four Corners	B.5-7
B.5.4 Plate Model of Cube with Normal Vectors	B.5-9
B.5.5 Cube Converted from Plates to Wires	B.5-10
B.5.6 GEMACS Input to Run MOM Wire-Grid Model of Cube	B.5-15
B.5.7 GEMACS Input to Run GTD Plate Model of Cube	B.5-16
B.5.8 GAUGE/GEMACS File Interaction	B.5-17
B.5.9 Color Coded Wires	B.5-19
B.5.10 Axes & Legend Displayed	B.5-20
B.5.11 Polar Plot of Scattered Field from a Cube	B.5-21
B.5.12 Rectangular Plot of Scattered Field from a Cube	B.5-22
C.1.1 GAUGE Graphical Processor Menu Tree	C.1-2
C.1.2 Graphics Database Arrays	C.1-3

List of Figures

<u>Figure</u>		<u>Page</u>
C.1.3	Model at Database Limits	C.1-4
C.1.4	World-Coordinates/Screen-Coordinates Conversion	C.1-6
C.1.5	Polygonal Faceting	C.1-6
C.1.6	Typical Menus	C.1-8
C.2.1	GEMACS Card Formats Read by the GP	C.2-1
C.2.2	Rotaions	C.2-3
C.2.3	Scale Factors	C.2-5
C.2.4a	Zoom Box	C.2-6
C.2.4b	Zoomed View	C.2-6
C.2.5	Translate Box	C.2-7
C.2.6	Redrawn Model	C.2-7
C.2.7	Parameters	C.2-8
C.2.8	Hidden Surface Plot	C.2-9
C.2.9	Wing of F-15 Nodel Drawn with Several Shrink Ratios	C.2-10
C.2.10	Point IDs and Element IDs	C.2-10
C.2.11	Skeleton Angles	C.2-12
C.2.12	Contour Plot on a Flat Plate	C.2-12
C.2.13	Normals on a Hidden Surface Plot	C.2.13
C.2.14	Show/Noshow Examples	C.2-19
C.3.1	Wires, Plates and Patches	C.3-4
C.3.2	Aperture on Cylinder	C.3-5
C.3.3	Aperture on End Cap	C.3-6
C.3.4	Aperture on Plate	C.3-6
C.3.5	Aperture Point on Cylinder	C.3-7
C.3.6	Aperture Point on End Cap	C.3-8
C.3.7	Aperture Point on Plate	C.3-8
C.3.8	Cylinder Orientation by Coordinate Cards	C.3-8
C.3.9	Renumbering	C.3-14
C.3.10	Translated and Scaled Plate	C.3-18

List of Figures

<u>Figure</u>	<u>Page</u>
C.3.11 Translated Cubes	C.3-19
C.3.12 Rotated Cubes	C.3-19
C.3.13 Connecting Plates	C.3-21
C.3.14 Connecting Wires	C.3-21
C.3.15 Connecting Plates from Translation	C.3-22
C.3.16 Reflected Truck	C.3-23
C.3.17 Projection onto a Plane	C.3-24
C.3.18 Wire Frame to Plates Conversion	C.3-26
C.3.19 Dummy Polygons to Plates Conversion	C.3-26
C.3.20 Lines and Curves	C.3-27
C.3.21 Picking Points	C.3-28
C.4.1 Format and Sample for Polygon Data File	C.4-1
C.4.2 Format and Sample for 2-D Plot Data File	C.4-3
C.4.3 Rectangular Plot	C.4-5
C.4.4 Polar Plot	C.4-6
C.4.5 Sample Contour Data File	C.4-8
C.4.6 Contour Plot	C.4-8
C.4.7 F-15 Colored by Depth and ID	C.4-9
C.4.8 EGA Colors	C.4-10
C.4.9 Default Colors for Element Types	C.4-12
C.4.10 GAUGE GP Post Processing Menu	C.4-14
C.4.11 Ray Trace Menu	C.4-15
C.4.12 Read Rays Menu	C.4-15
C.4.13 Ray Path File Format	C.4-16
C.4.14 Ray Plot of Cube	C.4-18
C.4.15 Numbered Rays on the Cube	C.4-18
C.4.16 Colored Rays on the Cube	C.4-19
C.4.17 Ray Plotting Options	C.4-19
C.4.18 Ray Show Mode Options	C.4-20

List of Figures

<u>Figure</u>	<u>Page</u>
C.4.19 Ray Selection by Source & Field Dialog Box	C.4-20
C.4.20 Ray Selection by Number of Bounces Dialog Box	C.4-21
C.4.21 Ray Selection by Path Number Dialog Box	C.4-22
C.4.22 Ray Paths on a GTD Cylinder	C.4-23
C.4.23 Creeping Waves on a GTD Cylinder	C.4-23
C.5.1 Text, Axes, Etc.	C.5-1
C.6.1 Grey Scale	C.6-1
D.1.1 Translator Input and Output Files	D.1-2
D.1.2 Initial Translator Input Screen	D.1-3
E.1.1 Files Interpreted by the GAUGE Output Translator	E.1-1
E.2.1 Initial Output Translator Input Screen	E.2-1
E.2.2 Typical ASCII Current Data	E.2-7
E.2.3 Typical Binary Current Data	E.2-8
E.2.4 Typical ASCII Field Data	E.2-8
E.2.5 Typical Binary Field Data	E.2-8
E.3.1 Binary File Format	E.3-3
E.3.2 File Header	E.3-4
E.3.3 File Header Bit Attribute Word	E.3-4
E.3.4 Multiple Binary File Format	E.3-5
E.3.5 Flow Diagram to Interpret GEMACS Binary File	E.3-6
E.3.6 Far Field GEMACS Binary File Format	E.3-7
E.3.7 Near Field GEMACS Binary File Format	E.3-8
F.2.1 Assembly Routines Called by GP Graphics Module	F.2-3
F.2.2 GP Top Level Data Flow Chart	F.2-4
F.3.1 Table of IT/MP Subroutines	F.3-1
F.4.1 Table of Output Translator Subroutines	F.4-1

This page intentionally left blank

C.4.5 RAY PATH VISUALIZATION

The primary method for visualizing computational electromagnetic (CEM) analysis data is to plot in 2 or 3 dimensions the radiation patterns generated. During this effort a new method of viewing the data was devised and implemented in GEMACS and GAUGE. GEMACS calculates the path the EM radiation will follow from a source to a requested field point. For this effort this path information was written off to an auxiliary file. This data is then displayed on the geometry via the CAD program GAUGE. This method of displaying path information on geometry has been used successfully in the computational fluid dynamics (CFD) field and shows great promise for CEM.

The syntax of the ray path command in GEMACS is given as follows:

```
RAYPTH [ON][OFF] LU=unit#  
where: unit# > NUMFIL
```

The RAYPTH ON and OFF commands must bracket the GEMACS EFIELD command(s) for which the user wants ray paths generated. That is the RAYPATH ON command must be placed before the EFIELD command(s) and the RAYPATH OFF command must be placed after the EFIELD command(s).

The remainder of this section will describe how to use the ray path plotting capabilities of GAUGE. The figures in this section are screen snapshots taken in standard VGA mode. The normal screen background is black but it has been changed from black to white for this document

C.4.5.1 RAY PATH PLOTTING

The GAUGE Graphical Processor (GAUGE GP) provides the ray plotting capabilities via the post processor menu as shown in the following figure (option Y).

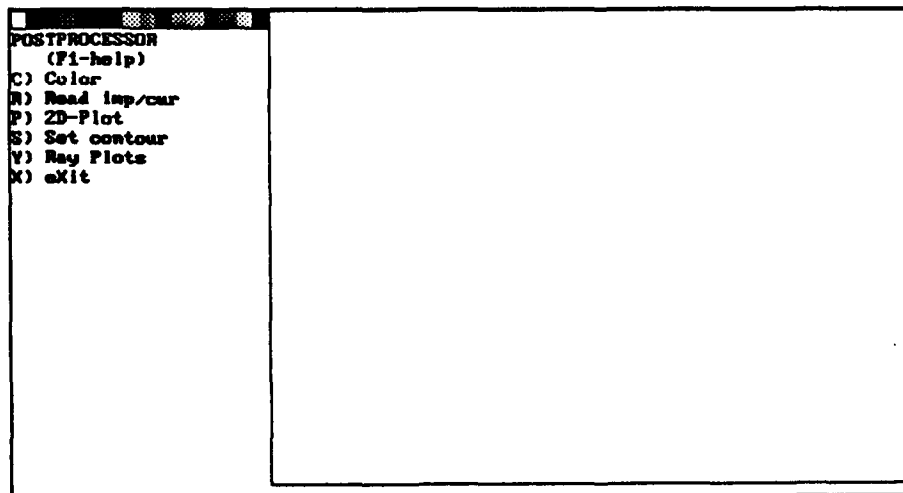


Figure C.4.10. GAUGE GP Post Processing Menu

When the *Ray Plots* option is chosen from the post processor menu, the RAY PLOTTING menu shown below is displayed. It should be noted that a geometry must be read before access to the RAY PLOTTING menu is granted. All of the ray path reading, plotting and labeling is performed from this menu.

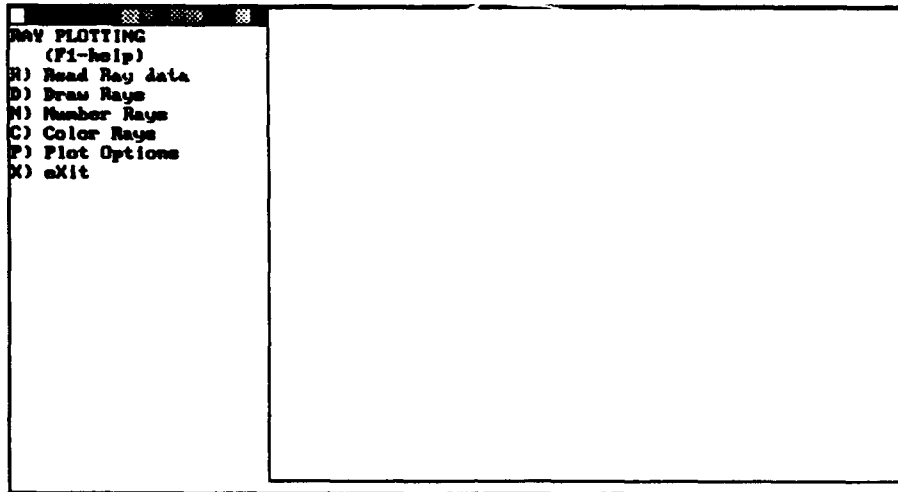


Figure C.4.11. Ray Trace Menu

C.4.5.1.1 Read Ray Data

Selecting the *Read Ray Data* item from the Ray Plotting menu brings up a standard GAUGE GP file selection menu utilized to browse for ray path data files (The ray path filenames should be of the form *.RAY). After a ray path data file has been selected and the *ACCEPT* (F9) item has been selected, the data is read into a GAUGE GP data structure for subsequent plotting on the screen. The Read Rays menu is shown in the following figure.

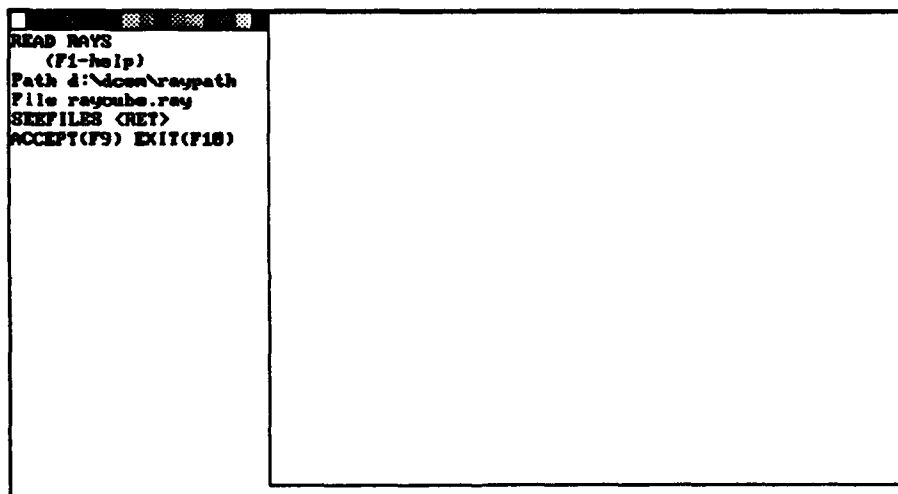


Figure C.4.12. Read Rays Menu

The format of the ray path data file that is generated is given in the following figure.

Comment	Line	Description				Example			
Control Line	1	NumRays	Mag.	Source Switch	Field Switch	2	2.3	1.0	0.0
Data Points	2	$x_1 \ y_1 \ z_1$		$x_2 \ y_2 \ z_2$		1.0 0.0 0.0		-0.5 0.5 -1.0	
	
	$m = 2 + \text{NumRays}$	$x_{n-1} \ y_{n-1} \ z_{n-1}$		$x_n \ y_n \ z_n$		-0.5 0.5 -1.0		1.0 0.0 0.0	
Control Line	$m+1$	NumRays	Mag	Source Switch	Field Switch	2	2.3	1.0	0.0
Data Points	$m+2$	$x_1 \ y_1 \ z_1$		$x_2 \ y_2 \ z_2$		1.0 0.0 0.0		0.5 0.5 0.0	
	
	$m=m+2+\text{NumRays}$	$x_{n-1} \ y_{n-1} \ z_{n-1}$		$x_n \ y_n \ z_n$		0.5 0.5 0.0		1.0 0.0 0.0	
Control Line	last	NumRays	Mag.	Source Switch	Field Switch	-1	0	0	0

Figure C.4.13. Ray Path File Format

The data file consists of the set of ray paths that were generated by a combination of the GEMACS RAYPTH and EFIELD commands. Each ray path set of data points is preceded by a control line. The *NumRays* entry on the control line gives how many ray segments make up the total ray path. The next value, *mag*, is the magnitude of the ray path. The *Source Switch* and *Field Switch* values tell whether the ray path source and field points are in the near field (1) or the far field (0) with respect to the global origin. The near field (x, y, z)-tuple are actual cartesian coordinates of the end of the ray segment whereas the far field (x, y, z)-tuple is the unit direction vector for that location. In the case of a far field *Field Switch* a unit the last (x, y, z)-tuple in the list represents a pointing direction from the previous (x, y, z)-tuple. For a far field source switch the first (x, y, z)-tuple is a unit vector pointing to the next (x, y, z)-tuple in the list. The switches only apply to the first (source switch) and last (field switch) (x, y, z)-tuples in the ray path. The last line of the data file is a control line with a -1 as the number of path segments. Complete listings of the GTD Plate model of a cube and its associated ray path data file are shown below.

Cube GEMACS Input Data File: RAYCUBE.GEM

```

$
$ GTD Plate model of a Cube test problem for GEMACS
$ Ray Path printing
$
$ Illustrates the RAYPTH (Ray Path) command
$
DISPLA ON LU=0
NUMFIL=17
FRQ=1000.0
SETINT PL EI ORDER=0,1
GMDATA=BOX
SRC=ESRC(BOX) DW=1.,0. R=5. THETA=70. PHI=0. ECC=0.0
$
RAYPTH ON LU=99
$
FLD=EFIELD(BOX) T1=110. P1=0.

```

```

$
RAYPTH OFF
$
END OF COMMANDS
$
$ Created by GAUGE Ver. 1.4
$ Decision-Science Applications
$
PT 1 1.0000 1.0000 -1.0000
PT 2 1.0000 1.0000 1.0000
PT 3 1.0000 -1.0000 -1.0000
PT 4 1.0000 -1.0000 1.0000
PL 1 4 3 1 2 4
$
END of Geometry

```

Cube Ray Path Data File: RAYCUBE.RAY

This file was generated by GEMACS as FOR099.USR and was manually renamed RAYCUBE.RAY.

```

1 4.8891490E+00 1.00 1.00
3.53553E+00 0.00000E+00 3.53553E+00 5.00000E+00 0.00000E+00 -2.18557E-07
2 1.9945090E-02 1.00 1.00
3.53553E+00 0.00000E+00 3.53553E+00 1.00000E+00 1.00000E+00 -1.00000E+00
1.00000E+00 1.00000E+00 -1.00000E+00 5.00000E+00 0.00000E+00 -2.18557E-07
2 4.6291230E-02 1.00 1.00
3.53553E+00 0.00000E+00 3.53553E+00 1.00000E+00 1.00000E+00 1.00000E+00
1.00000E+00 1.00000E+00 1.00000E+00 5.00000E+00 0.00000E+00 -2.18557E-07
2 1.9945110E-02 1.00 1.00
3.53553E+00 0.00000E+00 3.53553E+00 1.00000E+00 -1.00000E+00 -1.00000E+00
1.00000E+00 -1.00000E+00 -1.00000E+00 5.00000E+00 0.00000E+00 -2.18557E-07
2 4.6291110E-02 1.00 1.00
3.53553E+00 0.00000E+00 3.53553E+00 1.00000E+00 -1.00000E+00 1.00000E+00
1.00000E+00 -1.00000E+00 1.00000E+00 5.00000E+00 0.00000E+00 -2.18557E-07
2 1.6739670E-01 1.00 1.00
3.53553E+00 0.00000E+00 3.53553E+00 1.00000E+00 -3.04886E-07 -1.00000E+00
1.00000E+00 -3.04886E-07 -1.00000E+00 5.00000E+00 0.00000E+00 -2.18557E-07
2 4.9815790E-01 1.00 1.00
3.53553E+00 0.00000E+00 3.53553E+00 1.00000E+00 -2.93869E-07 1.00000E+00
1.00000E+00 -2.93869E-07 1.00000E+00 5.00000E+00 0.00000E+00 -2.18557E-07
-1 0.0000000E+00 .00 .00

```

C.4.5.1.2 Draw Rays

The *Draw Rays* menu item toggles the actual drawing of the ray paths in the GAUGE GP drawing windows. The following figure shows a plot of the ray paths bouncing off of a simple plate model of a cube.

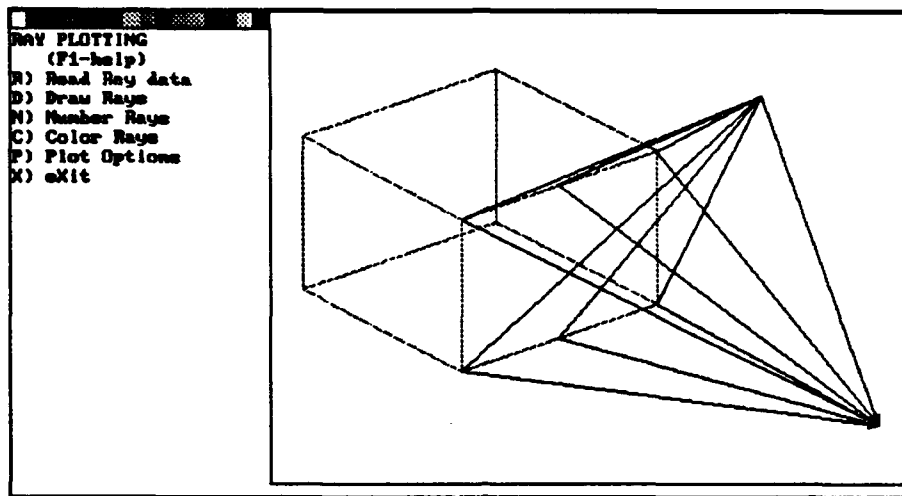


Figure C.4.14. Ray Plot of Cube

C.4.5.1.3 Number Rays

The actual ray paths in the data file do not have an identification number, but for the GAUGE ray tracing process they are numbered based on the order they were read from the data file. The *Number Rays* menu item places the id number on each segment of the ray paths that are plotted as shown in the following figure.

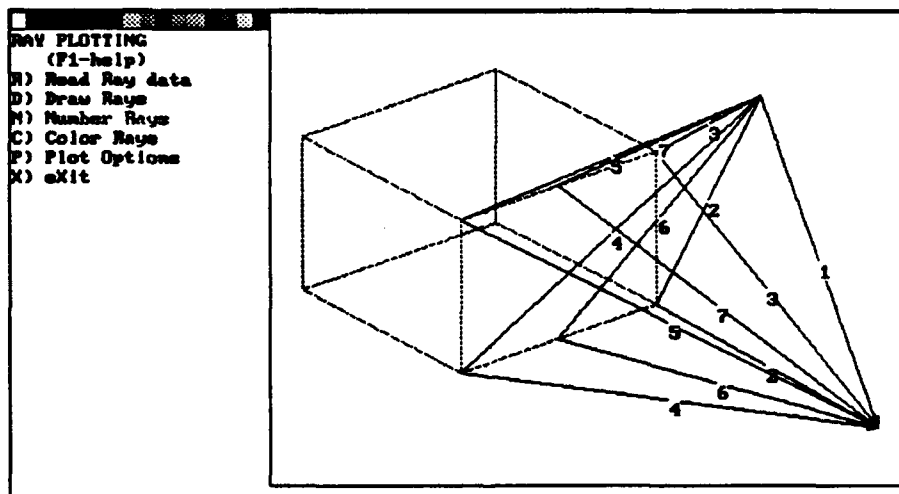


Figure C.4.15. Numbered Rays on the Cube

C.4.5.1.4 Color Rays

The *Color Rays* menu item sets the color of each ray based upon the magnitudes of the ray paths that were read. The colors are generated based upon a linear division of the magnitude values. The following figure illustrates the use of the *Color Rays* option. For this report the

colors of the ray paths are represented by different line styles. The solid line represents direct paths. The dashed line styles are proportional to the magnitude of the ray path.

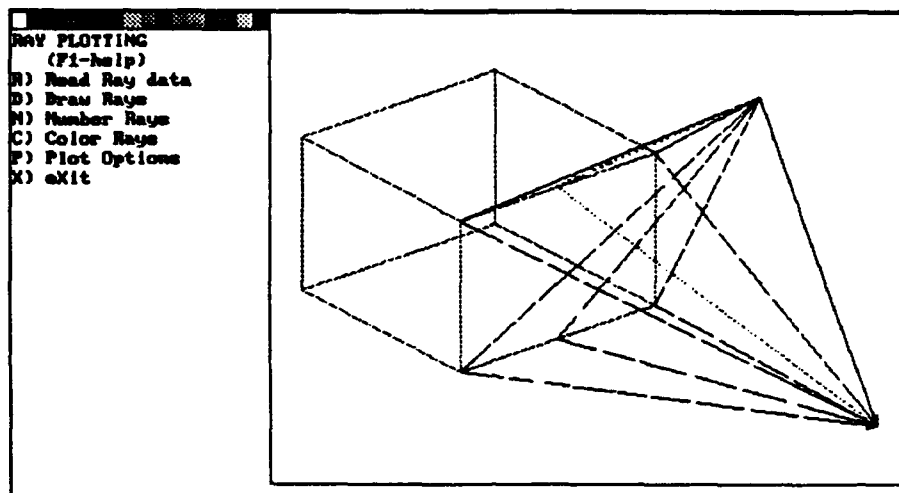


Figure C.4.16. Colored Rays on the Cube

C.4.5.1.5 Ray Plotting Options

The *Plot Options* menu item brings up a submenu that provides three different methods for plotting a subset of the ray paths. The following figure shows the RAY SHOW menu. Once a set of rays has been selected, then the user has the option to show only those rays, no-show only those rays, adding those rays to show or adding those rays to the no-show similar to the geometry show/no-show capability of GAUGE GP. A separate RAY SHOW MODE menu shown in Figure C.4.18 will be displayed after the ray path selection(s) has been made.

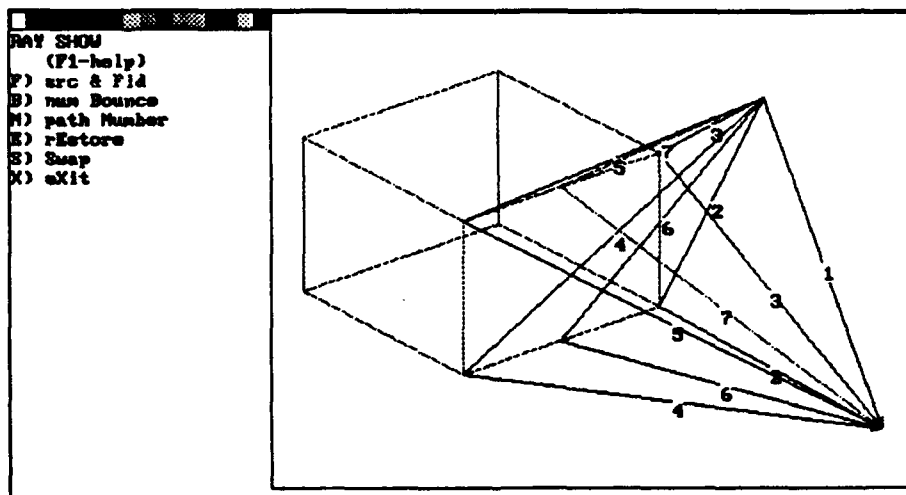


Figure C.4.17. Ray Plotting Options

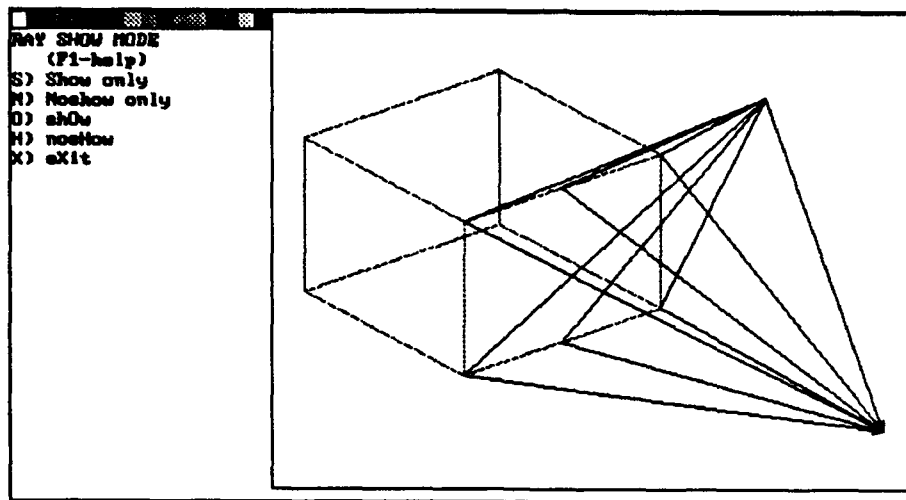


Figure C.4.18. Ray Show Mode Options

C.4.5.1.5.1 Source & Field

The first method of selecting a subset of ray paths to plot is by their source and field points. The following figure shows the menu used to select the source and field values to use. A range of values can be typed into each area corresponding to the n^{th} source or field point. If the numbers are left as 0, then all of the sources or fields are used. The selection of the paths to plot is based on ANDing the source locations selected with the field locations selected. If a ray path meets the condition of having its source in the selected source list and its field in the selected field list, then it is added to the selected paths list. This list is then used for showing or noShowing the rays.

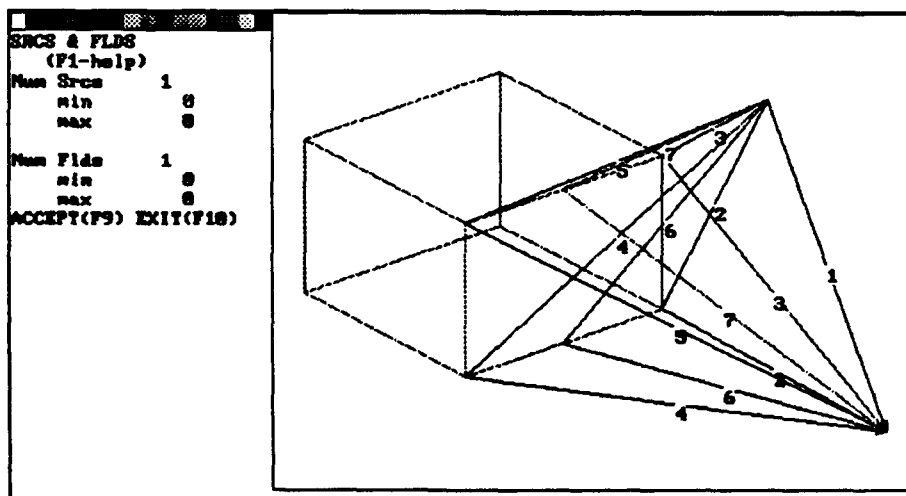


Figure C.4.19. Ray Selection by Source & Field Dialog Box

C.4.5.1.5.2 Number of Bounces

The second selection method is by the number of bounces in a ray path. The *num Bounce* method is shown in the following menu. Direct rays, from the source point(s) to the field point(s), are selected by the top toggle menu item. A carriage return toggles the menu item between OFF and ON. When a number is entered in the lower field only, those rays with that number of bounces will be selected. A zero bounce ray is equivalent to direct rays.

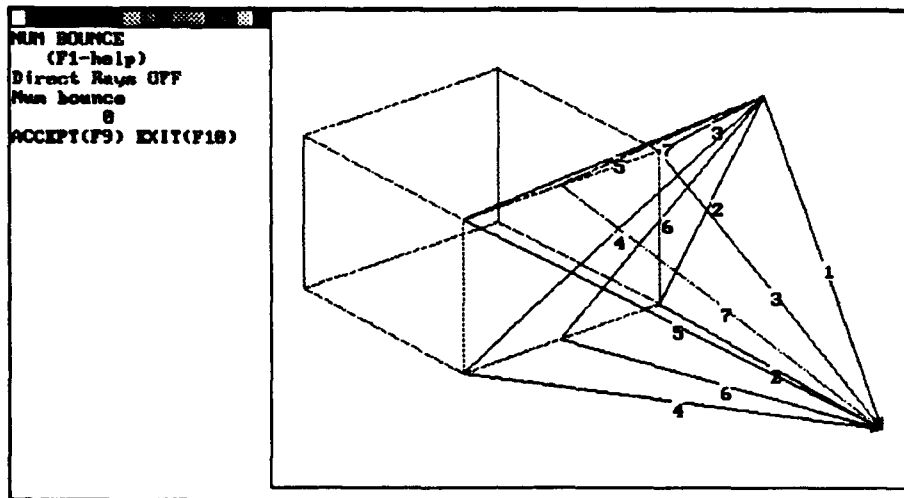


Figure C.4.20. Ray Selection by Number of Bounces Dialog Box

C.4.5.1.5.3 Path Number

The last selection method is by the number of the ray path. The BY PATH NUM menu provides for selecting the ray paths by the order they were read into the database. This menu is shown in Figure C.4.21. Direct rays for a given field pattern are stored first with all higher order rays for that field coming after the direct rays. This menu should be used in conjunction with the numbering of the rays on the screen (see Section C.4.5.1.3) to narrow the selection of ray paths. The menu can accept 3 ranges of path numbers. If a range is left blank or filled with zeros, it is not considered. Both the *Num Min* and *Max* entries of the range must be entered correctly to select the ray paths. Only those rays that fall within the number range will be selected.

C.4.5.1.5.4 Restore

A ray path data set that has been partitioned by the ray show/no-show option may be restored to the original state of showing all ray paths using this menu item. This option restores all ray paths in memory to show status.

C.4.5.1.5.5 Swap

A portion of the ray paths that has been assigned the show status may be changed to the no-show status and vice versa.

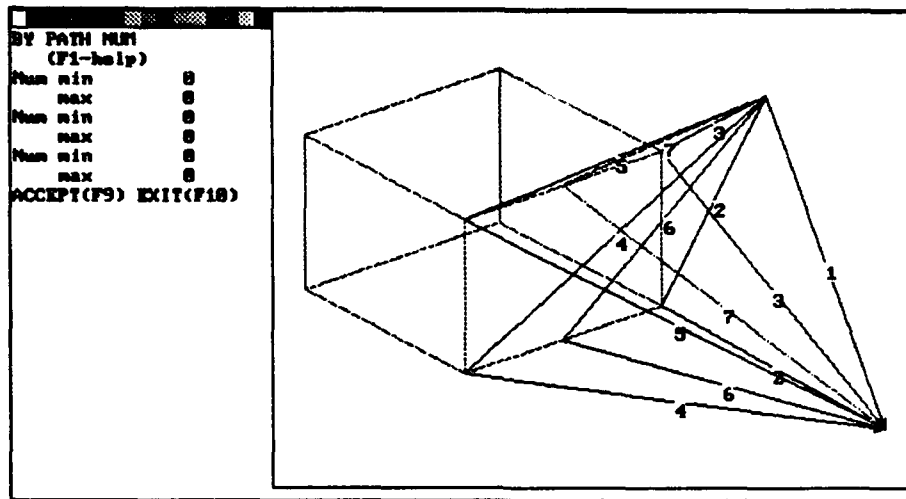


Figure C.4.21. Ray Selection by Path Number Dialog Box

C.4.5.2 RAY PATHS ON CYLINDER EXAMPLE

The next pair of figures shows an example of using GEMACS to calculate the scattering from a GTD cylinder. There is one source point and one field point. The left figure shows all the ray paths that were calculated from the source to the field. The right figure shows a top view of the detail on ray paths 3 and 4. These two paths illustrate the ray creeping around the cylinder. Ray path 3 creeps around a small quadrant (<45 degrees), while ray path 4 goes all the way around the cylinder before it detaches and proceeds to the field point.

It is straightforward to verify that ray path 3 only traverses a small quadrant of the cylinder. First, the magnitude of ray path 3 is only slightly less than the magnitude of ray path 2 which has a single bounce off the cylinder. Second, the magnitude of ray path 4 is much less than that of ray path 3, and it can be concluded that ray path 4 traverses the entire geometry in the figure. Third, any waves that traverse more than 2π degrees around the cylinder are excluded by GEMACS because these waves are greatly attenuated.

This ability of the ray path plotting can be used to visualize the coupling between antennas on opposite sides of a fuselage for example. The GEMACS input and ray path listings for the cylinder example are given following Figures C.4.22 and C.4.23.

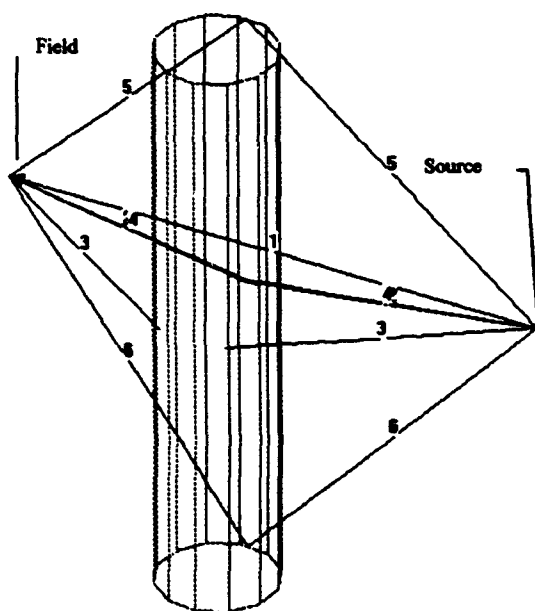


Figure C.4.22. Ray Paths on a GTD Cylinder

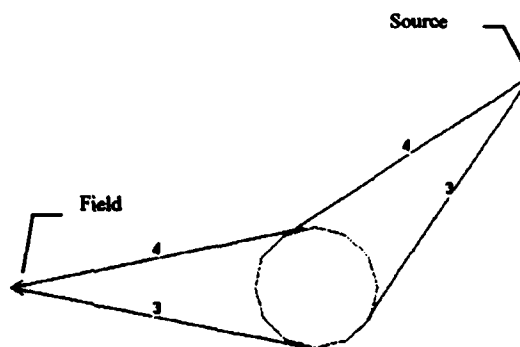


Figure C.4.23. Creeping Waves on a GTD Cylinder

Cylinder GEMACS Input Data File: RAYCYL.GEM

```
$
$ Cylinder test problem
$
$ Illustrates the RAYPTH (Ray Path) command
$
DISPLA ON LU=0
NUMFIL=17
FRQ=1000.0
SETINT PL EI ORDER=0-3
GMDATA=CYLIN
SRC=ESRC(CYLIN) DW=1.,0. R=5. THETA=90. PHI=0. ECC=0.0
RAYPTH ON LU=99
FLD=EFIELD(CYLIN) T1=90. P1=180. R1=5.
RAYPTH OFF
$
END OF COMMANDS
$
$
CY 1 1. 1. 10. 0
EC 1 1 0. 0.
EC 2 -1 180. 0.
$
END of Geometry
```

Cylinder Ray Path Data File: RAYCYL01.RAY

This file was generated by GEMACS as FOR099.USR and was manually renamed RAYCYL01.RAY.

1	2.4453194E+00	1.00	1.00			
3.53553E+00	3.53553E+00	-2.18557E-07	-5.00000E+00	-4.37114E-07	-2.18557E-07	
2	6.3531101E-01	1.00	1.00			
3.53553E+00	3.53553E+00	-2.18557E-07	-3.82683E-01	9.23880E-01	-2.18557E-07	
-3.82683E-01	9.23880E-01	-2.18557E-07	-5.00000E+00	-4.37114E-07	-2.18557E-07	
2	1.7755465E-01	1.00	1.00			
3.53553E+00	3.53553E+00	-2.18557E-07	8.34242E-01	-5.51399E-01	-2.18557E-07	
-2.00000E-01	-9.79796E-01	-2.18557E-07	-5.00000E+00	-4.37114E-07	-2.18557E-07	
2	2.2705419E-05	1.00	1.00			
3.53553E+00	3.53553E+00	-2.18557E-07	-5.51399E-01	8.34242E-01	-2.18557E-07	
-2.00000E-01	9.79796E-01	-2.18557E-07	-5.00000E+00	-4.37114E-07	-2.18557E-07	
2	3.8389534E-02	1.00	1.00			
3.53553E+00	3.53553E+00	-2.18557E-07	-3.82684E-01	9.23880E-01	5.00000E+00	
-3.82684E-01	9.23880E-01	5.00000E+00	-5.00000E+00	-4.37114E-07	-2.18557E-07	
2	4.6092547E-02	1.00	1.00			
3.53553E+00	3.53553E+00	-2.18557E-07	-3.82684E-01	9.23879E-01	-5.00000E+00	
-3.82684E-01	9.23879E-01	-5.00000E+00	-5.00000E+00	-4.37114E-07	-2.18557E-07	
-1	0.0000000E+00	0.00	0.00			

***MISSION
OF
ROME LABORATORY***

Mission. The mission of Rome Laboratory is to advance the science and technologies of command, control, communications and intelligence and to transition them into systems to meet customer needs. To achieve this, Rome Lab:

- a. Conducts vigorous research, development and test programs in all applicable technologies;
- b. Transitions technology to current and future systems to improve operational capability, readiness, and supportability;
- c. Provides a full range of technical support to Air Force Materiel Command product centers and other Air Force organizations;
- d. Promotes transfer of technology to the private sector;
- e. Maintains leading edge technological expertise in the areas of surveillance, communications, command and control, intelligence, reliability science, electro-magnetic technology, photonics, signal processing, and computational science.

The thrust areas of technical competence include: Surveillance, Communications, Command and Control, Intelligence, Signal Processing, Computer Science and Technology, Electromagnetic Technology, Photonics and Reliability Sciences.